CLAIMS

1. A method for modeling injection of a fluid into a mold defining a three dimensional cavity, the method comprising the steps of:

(a) providing a three dimensional solid computer model defining the cavity;

(b) discretizing a solution domain based on the solid model;

(c) specifying boundary conditions;

(d) solving for filling phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based on the boundary conditions to provide respective filling solutions therefor for at least the portion of the solution domain;

(e) solving for packing phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based on respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor for at least the portion of the solution domain; and

(f) determining whether at least one of the respective filling phase solutions and packing phase solutions are acceptable.

2. The method according to claim 1, wherein the filling phase process variables and packing phase process variables are selected from the group consisting of density, fluidity, mold cavity fill time, mold cavity packing time, pressure, shear rate, shear stress, temperature, velocity, viscosity, and volumetric shrinkage.

3. The method according to claim 1, further comprising the steps of:

(g) modifying at least one of the discretized solution domain and the boundary conditions in the event at least one of the respective filling phase solutions and packing phase solutions is determined to be unacceptable; and

(h) repeating steps (d) through (g), iteratively, until the respective filling phase solutions or packing phase solutions are determined to be acceptable.

4. The method according to claim 1, further comprising the step of:

displaying in graphics format a filling phase solution selected from the group consisting of fill time, pressure, shear rate, shear stress, temperature, velocity, and viscosity.

5. The method according to claim 1, further comprising the step of: displaying in graphics format a packing phase solution selected from the group consisting of density, packing time, pressure, shear rate, temperature, velocity, viscosity, and volumetric shrinkage.

6. A method for modeling injection of a fluid into a mold defining a three dimensional cavity, the method comprising the steps of:

(a) providing a three dimensional solid computer model defining the cavity;

(b) discretizing a solution domain based on the solid model;

(c) specifying boundary conditions;

(d) solving for filling phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based on the boundary conditions to provide respective filling phase solutions therefor for at least some of the portion of the solution domain; and

(e) determining whether the respective solutions are acceptable for injection of the fluid during filling of the mold cavity.

7. The method according to claim 6, wherein the discretizing step (b) comprises the substep of generating a finite element mesh based on the solid model by subdividing the model into a plurality of connected elements defined by a plurality of nodes.

8. The method according to claim 6, wherein the boundary conditions are selected from the group consisting of fluid composition, fluid injection location, fluid injection temperature, fluid injection pressure, fluid injection volumetric flow rate, mold temperature, cavity dimensions, cavity configuration, and mold parting plane, and variations thereof.

9. The method according to claim 6, wherein the solving step (d) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for fluidity for at least some of the portion of the solution domain;

(ii) solving for pressure for at least some of the portion of the solution domain; and

(iii) calculating velocity for at least some of the portion of the solution domain.

10. The method according to claim 9, wherein the solving step (d) utilizing the conservation of energy equation comprises the substep of calculating viscosity for at least some of the portion of the solution domain.

11. The method according to claim 10, wherein the viscosity calculating substep is based on temperature.

12. The method according to claim 11, wherein at least one of velocity and viscosity is calculated iteratively, until pressure converges.

13. The method according to claim 12, further comprising the substep of determining free surface evolution of the fluid in the cavity based on velocity.

14. The method according to claim 13, further comprising the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution.

15. The method according to claim 14, wherein free surface evolution is determined iteratively, until the cavity is filled.

16. The method according to claim 6 further comprising the steps of:

(f) solving for packing phase process variables using conservation of mass, conservation of momentum, and conservation of energy equations for at least a portion of the solution domain based on respective states of the process variables at termination of filling, to provide respective packing phase solutions therefor for at least some of the portion of the solution domain; and

(g) determining whether the respective packing phase solutions are acceptable for injection of the fluid during packing of the mold cavity.

17. The method according to claim 16, wherein the solving step (f) utilizing the conservation of mass and conservation of momentum equations comprises the substeps of:

(i) solving for fluidity for at least some of the portion of the solution domain;

(ii) solving for pressure for at least some of the portion of the solution domain; and

(iii) calculating velocity for at least some of the portion of the solution domain.

18. The method according to claim 16, wherein the solving step (f) utilizing the conservation of energy equation comprises the substep of calculating viscosity for at least some of the portion of the solution domain.

19. The method according to claim 18, wherein the viscosity calculating substep is based on temperature.

20. The method according to claim 19, wherein at least one of velocity and viscosity is calculated iteratively, until pressure converges.

21. The method according to claim 20, further comprising the substep of calculating temperature based on at least one of a convective heat transfer contribution, a conductive heat transfer contribution, and a viscous dissipation contribution.

22. The method according to claim 21, further comprising the step of:

(h) calculating mass properties of a component produced in accordance with the boundary conditions.

23. The method according to claim 22, wherein the mass properties are selected from the group consisting of component density, volumetric shrinkage, component mass, and component volume.

24. The method according to claim 22, wherein at least one of velocity, viscosity, and mass properties is calculated iteratively, until a predetermined pressure profile is completed.

25. The method according to claim 7, wherein the mesh generating substep comprises generating an anisotropic mesh in thick and thin zones such that mesh refinement provides increased resolution in a thickness direction without increasing substantially mesh refinement in a longitudinal direction.